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ENFOR Project P-228

Feasibility Study on the Conversion of an Oil/Gas Heating Plant at C.F.B. Borden to a Biomass Fuel Plant

by

Charles G. Turner & Associates Ltd.

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Contractor's Final Report [1/]
DSS Contract 47SS.KH405-1-0194

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September 1982

CHARLES G. TURNER & ASSOC. Ltd.
CONSULTING ENGINEERS

D.S.S. CONTRACT No. 47SS. KH405-81-0194
Feasibility Study
Conversion of an Oil/Gas Heating Plant at
C.F.B. Borden to a Biomass Fuel Plant

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FEASIBILTIY STUDY ON THE CONVERSION OF AN OIL/GAS HEATING PLANT AT CFB BORDEN, ONTARIO TO A BIOMASS FUELED PLANT
DSS File 47ss.KH405-81-0194

INTRODUCTION

Energy costs for fossil fuels have risen significantly in the last decade. The desireability of utilizing wood for energy production appears an attractive alternative to fossil fuels.

Forest waste and tree plantations are valuable sources of energy. In many parts of Ontario there are wood supplies which could be used for energy production.

The Department of National Defence operates numerous facilities across Canada which require large quantities of fossil fuels, principally oil and gas for heating of the facilities. At one of these locations, C.F.B. Borden, Ontario, five main Central Heating Plants and approximately 140 small boilers are used to heat the base camp.

FEASIBILITY STUDY ON THE CONVERSION OF AN OIL/GAS HEATING PLANT AT CFB BORDEN, ONTARIO TO A BIOMASS FUELED PLANT
DSS File 47ss.KH405-81-0194

OBJECT

To determine the feasibility of converting oil/gas fired energy plants at C.F.B. Borden to wood fired energy production and assess the quantity of wood available from mill and logging residue, stand conversion, tree salvage, timber management and energy plantation.

To undertake the study, one medium sized energy plant, Building No. 098, has been designated by C.F.B. Borden as a representative model and the investigation has focused on the feasibility of converting this plant to wood produced energy.

FEASIBILITY STUDY ON THE CONVERSION OF AN OIL/GAS HEATING PLANT AT CFB BORDEN, ONTARIO TO A BIOMASS FUELED PLANT
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SUMMARY

The investigation covers the various wood lots, mill waste, the plantation of hybrid trees on the varied abandoned lots within the area and the use of the various woodlots within the base camp. The supply and costs associated with transportation and delivery have also been investigated.

The investigation also covers the feasibility of converting the existing boilers from gas to wood firing, capital cost, manpower and operating costs.

THE WOOD FUEL SUPPLY

The Forest Resources of Huronia District

Mill Residues

Forests of Canadian Forces Base Borden

Assessment of Biomass from Energy Plantations

References

WOOD SUPPLY

THE FOREST RESOURCES OF HURONIA DISTRICT

The productive forests of Huronia District are estimated to occupy 218,438 ha. (539,542 acres). This represents about 34% of the total land base. Table 1 summarizes the various land classes and water component.

TABLE 1

SUMMARY OF PRODUCTIVE, PROTECTION, NON-PRODUCTIVE AND NON-FORESTED AREAS IN HURONIA DISTRICT, 1981

	Ha.	% Area	% of Land Area
Productive Forest	218,438	28.25	34.05
Protection Forest	22,748	2.94	3.54
Non-Productive Forest	22,133	2.86	3.45
Non-Forested	378,098	48.91	58.94
Total Land Area	641,417	82.96	99.98
Water	131,595	17.02	
Total Area	773,012	99.98	

Source: Ministry of Natural Resources

Approximately 13,500 ha. of productive forest are identified with Crown land, while 185,500 ha. are in private ownership. Over 11,600 ha. of productive forest are identified with agreement forest, mainly County forests. Base Borden has nearly 4,800 ha. The remainder is to be found in parks and Indian Reserves.

The productive forests in the district are predominantly hardwoods which occupy nearly 63%, while conifers constitute 37% of the productive forest lands. The principal hardwood species are hard maple and poplar, with oak, basswood, ash, red maple, hickory, ironwood and yellow and white birch in lesser amounts. The conifers are red, jack, white pine, hemlock and spruce.

The 1976 agricultural census for the study area reports 29,650 hectares of woodland. This represents about 16% of the productive forest on patented or private lands. The M.N.R. office for Huronia District estimates about 12,416 ha. of private woodlands under woodlot improvement agreements on private lands. It is estimated that the Ministry services an additional 20,000 acres (8,097 ha.) in terms of extension services.

A significant proportion of productive forest is identified with small holders, recreational and residential estates that surround Lake Simcoe and the smaller lakes in the study area.

A major part of the Crown land holdings is located at the Midhurst research station and nursery.

THE BIOMASS

Data on the biomass is limited to the existing forest inventory and estimates of volumes of the various species that exist under management or ownership patterns. It is interesting to note in a comparison of the productive forest in Huronia District between the 1953 inventory* and the current inventory* there has been a 10% increase in the area of productive forests. Much of this increase is believed to be associated with plantations.

Recent estimates* indicate that the productive forests in Huronia District contain 17 million cubic meters of hardwoods and 7.5 million cubic meters of conifers. Current annual increments for these two types are estimated at 316.3 thousand cubic meters and 164.3 cubic meters respectively.

Table 2 presents a summary of the volumes and current annual increment under the various management groups.

*Ministry of Natural Resources, Province of Ontario.

TABLE 2

VOLUMETRIC SUMMARY, PRODUCTIVE FORESTS
OF HURONIA DISTRICT BY OWNERSHIP CLASSES

Land Ownership	Productive Forest Ha.	Volume M^3	Total C.A.I. M^3	Volume/ Ha. M^3/Ha.	C.A.I./ Ha. M^3/Ha.
Crown	13,517	2,157,696	33,830	159.6	2.50
Private	185,512	19,239,454	381,293	103.7	2.06
Parks	2,139	375,160	5,523	175.4	2.58
Indian Reserve	818	108,620	1,832	132.8	2.24
Agreement Forests	11,672	1,957,502	45,292	167.7	3.88
Federal	4,780	780,026	12,889	163.2	2.70
Totals	218,438	24,618,458	480,659		
Averages				112.7	2.20

The estimate of current annual increment totalling 480,000 M^3 is a reasonable estimation of the annual harvest that could be taken without depleting the growing stock base.

Source: Ontario Ministry of Natural Resources

ASSESSMENT OF LOGGING RESIDUES

The data concerning the recovery of logging wastes or residues for the study area is very limited. Most studies on the subject have dealt with the traditional sawlog and pulpwood operations. Some research has been carried out on the harvesting of low grade stands and the retrieval of residual trees. *

The woodlands in the study area are predominantly small (2 to 40 ha.) hardwood woodlots. Past harvesting has been carried out as periodic selective cuts involving small volume.

Discussions with local logging contractors indicated that very little residue is left after a selective cut since the branchwood over 7 cm. in diameter usually is retrieved as firewood. Only the smaller branches remain.

It is felt that the retrieval of this material would be extremely costly compared with other sources of available biomass.

In approaching the matter of logging residue a review was made of the Ministry of Natural Resources records on volumes of wood marked and advertised for sale from private lands and volumes of wood cut from agreement forests. The volumes reported are considered representative of the known annual logging activity and an indicator of the potential logging residue that might become available annually as a source of energy fuel.

Table 3 provides a summary of the volume wood cut from agreement forests in Huronia District between April 1980 and March 1981.

* ENFOR - P.152

TABLE 3

VOLUME OF WOOD CUT FROM AGREEMENT FORESTS IN HURONIA DISTRICT BETWEEN APRIL 1980 AND MARCH 1981

Saw Logs	17,010 cu. ft.	=	486 m^3
Poles	17,693 cu. ft.	=	505 m^3
Boltwood and Pulpwood	445 cords	=	1,081 m^3
OPC Pulpwood	10,393 cords	=	25,240 m^3
Gross Merchantable Volume		=	27,312 m^3
Fuelwood Retrieved		=	7,424 m^3
			34,736 m^3

Source: M. N. R. Midhurst

From the data in Table 3 it is concluded that the Gross Merchantable Volume of 27,312 m^3 would represent 74%* of the original Gross Volume and that the balance of 26%* would include 7,424 m^3 of retrieved fuelwood and 2,168 m^3 of branchwood.

The Ministry of Natural Resources Summary of Private Timber marked and advertised for the year April 1980 to March 1981 indicates a total of 4,179 cords or 10,149 m^3 of fuelwood material for sale. Applying the same calculations as done for the agreement forests this should indicate that 2,964 m^3 of branchwood resulted from that year's cut on the private lands.

The branchwood biomass from these two sources in that 12 month period would total 5,132 m^3.

It is reasonable to presume that certain fluctuations in this annual volume would result from variations in forest product demand from year to year.

*Enfor P. 152.

MILL RESIDUES

Mill residues in the form of sawdust, slabwood edgings and bark constitute a recoverable biomass supply suitable for conversion into energy fuel. The assessment of the potential supply of such materials was accomplished by a survey of mills within a 125 km. radius of Base Borden.

In all 22 mills were contacted. A questionnaire was designed to assist in the collection of pertinent data which was carried out by personal contact with mill operators. Table 4 shows the mills surveyed in terms of their capacity.

TABLE 4

	Size Class*	No. in Area	No. Surveyed
B	10,000 - 25,000 MFBM	2	2
D	2,000 - 5,000 MFBM	11	8
E	1,000 - 2,000 MFBM	4	4
F	0 - 1,000 MFBM	42	8

It should be noted that some operators were reluctant to supply answers to every question while others could not respond in the weights and measures indicated. Adjustments were made to standardize the data into uniform units.

An estimate has been made of the potential volume of residues generated from the area mills, the present utilization of the residue and their availability for this particular project.

The survey showed that one large (Class B) mill in the area utilizes its residues for in-house energy needs, while the second mill sold its residues.

* Primary wood using industries in Ontario.

The medium (Class D) mills usually disposed of their residues, the sawdust being bought by farmers while the slabs were either sold as firewood or chipped for other commercial markets. Most mills have difficulty disposing of bark.

Table 5 summaries the mills surveyed in terms of their production of residues, the availability of such materials to this project and the estimated cost per delivered green tonne at the Base Borden plant. Only one mill was prepared to guarantee delivery of 3,600 plus green tonnes of sawdust at a stated price for the next two years. This price of $16.53 per green tonne provided a good indicator of the current value of sawdust. It would appear that there should be no difficulty in obtaining adequate supplies of this type of fuel at that price. The availability of slabwood, edgings and other forms of solid wood residue is not promising as secondary wood using industries depend on such materials for chipping.

TABLE 5

SUMMARY OF MILLS SURVEYED WITHIN A 125 KM RADIUS OF BASE BORDEN WITH PARTICULAR REFERENCE TO AVAILABLE WASTE AND COST AT BASE BORDEN PLANT

MILL LOCATION	SIZE OR CLASS	DISTANCE TO PLANT KMS	KNOWN WOOD WASTE PRODUCT IN TONNES PER YEAR SAWDUST	KNOWN WOOD WASTE PRODUCT IN TONNES PER YEAR SLABS	AVAILABLE WOOD WASTE PRODUCT IN TONNES PER YEAR SAWDUST	AVAILABLE WOOD WASTE PRODUCT IN TONNES PER YEAR SLABS	SUGGESTED PER TONNE COST AT PLANT SAWDUST	SUGGESTED PER TONNE COST AT PLANT SLABS
Gormley	D	0 to 80	4000	-	4000	-	16.53	-
Shelbourne	D	"	2860	3400	2860	-	N/A	
Orillia	E	"	590	-	590	-	N/A	
Barrie	F	"	1340	-	1340	-	16.53	-
Hillsburg	F	"	N/A	-	-	-	N/A	
Wyebridge	F	"	N/A	-	-	-	N/A	
Shanty Bay	F	"	N/A	-	-	-	N/A	
Durham	B	80 to 100	N/A	-	-	-	N/A	
Guelph (2)	D	"	N/A	-	-	-	N/A	
Owen Sound	D	"	1250	3400	1250	3400	14.33	30.86
Walters Falls	D	"	1700	4550	1700	4550	14.33	30.86
Gravenhurst	D	"	4000	6875	4000	-	N/A	
Hanover	E	"	980	N/A	980	-	17.63	-
Bracebridge	F	"	70	-	70	-	12.12	-
Owen Sound	F	"	N/A	-	-	-	N/A	
Bracebridge	E	"	4900	3570	4900	-	14.33	-
Huntsville	B	100 to 125	N/A	-	1610	-	16.53	-
Petersburg	D		1875	5100	1875	5100	16.53	-

TABLE 6

INCREMENTAL COSTS FOR DELIVERED WOOD FROM THREE SOURCES
ASSUMING INFLATION RATES OF 16, 12, and 8 PERCENT TO THE YEAR 2000

YEAR	RANGE	SAWDUST $/GREEN TONNE			PULP/BOLTWOOD S.E. B. BORDEN*			ENERGY PLANTATION $ GREEN ** TONN		
		16%	12%	8%	16%	12%	8%	16%	12%	8%
1982	minimum	16.53	16.53	16.53	7.42	7.42	7.42	18.57	18.57	18.57
	maximum				15.68	15.68	15.68	35.53	35.53	35.53
1987	minimum	34.53	29.14	24.29	15.58	13.07	10.90	39.00	32.73	27.29
	maximum				32.94	27.55	23.04	74.63	62.62	52.20
1992	minimum	72.92	51.34	35.68	32.72	22.26	16.01	81.91	57.67	40.09
	maximum				69.17	48.71	33.85	156.73	110.34	76.70
1997	minimum	153.16	90.47	52.43	68.72	40.60	23.53	172.04	101.64	58.90
	maximum				145.30	85.83	49.74	329.19	194.47	112.70
2000	minimum	239.07	127.67	66.05	107.26	57.02	29.63	268.55	142.80	74.20
	maximum				226.79	120.59	62.66	513.83	273.21	141.97

* ENFOR P-152

** Pfeiffer - University of Guelph

O.M.N.R. 1978
Hybrid Poplar as an Agricultural
Enterprise in Eastern Ontario

FORESTS OF CANADIAN FORCES BASE BORDEN

General

This assessment is based on information provided by the Great Lakes Forest Research Centre and included a forest cover map prepared by the Ministry of Natural Resources in 1972 and then updated with 1979 field survey data, area, growth, and volumetric summaries.

Using this information base, the area of productive forests on the Base was determined to be about 4,664 hectares. This was made up on 52% hardwood stands and the balance of 48% coniferous.

Poplar is the most dominant hardwood species while pine in plantations is the most prevalent coniferous species. There are some natural stands of cedar in the valley and wet areas, and a small maple stand utilized for the production of maple syrup.

With the exception of the maple stand, most of the hardwood areas consist of uneven-aged poplar mixed with other hardwood species in lesser amounts. In general these stands are in poor condition. A program of silvicultural treatments or one of stand conversion would yield a considerable annual volume of low grade logs and biomass for fuel. Table 7 shows a summary of the Base forests and indicates area, total volume, current annual increment by working groups.

TABLE 7

SUMMARY OF THE BASE FORESTS SHOWING AREA, GROSS VOLUME AND CURRENT ANNUAL INCREMENT BY WORKING GROUPS

Working Group	Area in Hectares	Gross Volume M^3	Current Annual Increment M^3	Volume M^3/hs	Current Annual Increment M^3/ha
Conifers					
Red Pine	912.5	167,616	4,054.0	187.7	4.44
White Pine	242.0	46,085	1,243.7	190.4	5.14
Scots Pine	214.5	36,460	820.5	170.0	3.83
Jack Pine	121.0	22,135	304.2	182.9	2.51
Cedar	690.0	91,250	893.8	132.2	1.30
Others	48.0	4,216	99.6	87.8	2.08
Subtotal	2,228.0	367,762	7,415.8	165.1	3.33
Hardwoods					
Poplar	2,161.0	295,040	5,371.5	136.5	2,49
Hard Maple	75.5	13,967	140.8	185.0	1.86
Soft Maple	167.0	12,725	307.5	76.2	1.84
Others	32.0	2,666	40.0	83.3	1.25
Subtotal	2,435.5	324,398	5,859.8	133.2	2.41
TOTAL	4,663.5	692,160	13,275.6	148.4	2.85

THE SOUTH EAST AREA

The base forest lands can be delineated into two distinct groups: those occupying lands where militar activity is high, and those where it is low or non existent. The study has determined that an area in the south east of the Base representing about 39% of the total Base forest lands has little or no military activity. This area has been referred to in this report as the South East Area. Table 9 shows the area and volumetric data for this area.

TABLE 8

DATA BASE FOR THE SOUTH EAST AREA
SHOWING AREA AND VOLUME DATA BY WORKING GROUPS

Working Group	Area	Percentage of Total Base Volume for Working Group	Volume M^3	Current Annual Increment M^3	Volume Per Ha M^3	Current Annual Increment Per Ha. M^3
Poplar	1,171	54.0	159,321	2,900.0	136	2.48
Conifer	212	9.5	34,937	704.0	156	3.32
Other Hardwoods	28	10.2	2,994	49.8	107	1.78
Barren Scattered	135					
Unclassified	229					
	1,775 ha.					

Note: Area totalled from FRI Sheet

The area of each working group in the South East area was totalled from the F.R.I. map. These working group totals were transformed into percentages of the total working group area in the Base. These percentages were applied to the Volume Summary Chart of Base Borden (Table 7) to calculate the volume of each working group in the South East area.

The poplar working group was separated from the other hardwoods for reasons of difference in utilization and prescribed management practices. As well, Poplar is the most significant source of fuel biomass on the Base.

Poplar volumes for the South East area were calculated using 54% of the total volume of Poplar on the Base*. The following chart was used to calculate annual available biomass from Poplar.

Age Group	Volume M^3	C A I M^3	M A I M^3
1 - 20	-	-	-
21 - 40	15,356	645	314
41 - 60	87,118	1,944	1,645
61 - 80	32,589	236	436
80 -100	24,257	75	284

The following sections of the report discuss each working group with respect to management practice, potential fuel biomass and possible regeneration options.

Barren and Scattered and areas with military activity were noted as other potential sources of fuel biomass.

Finally, a volume summary for all potential sources and cost summaries for recovery from each working group have been provided.

POTENTIAL BIOMASS FROM THE POPLAR WORKING GROUP IN THE SOUTH EAST AREA

There are 1,171 ha. of Poplar (54% of the total for the working group) in the South East Area. The management objective adopted was to improve the stand and manage for maximum economic yields. There are two management assumptions and constraints.

* Federal Forest Inventory - Base Borden.

Assumption 1

The Poplar stands in their present condition have no other value except for fuel.

Assumption 2

A rotation age of 60 years was based on intersection of the C.A.I. and M.A.I. (regeneration delay considered).

Constraint 1

All residual hardwoods of sawlog or seed trees potential would be managed accordingly.

Constraint 2

The size of openings would be no larger than .1 hectare as soil is very unstable.

If the present overmature stands are removed during the first 10 years, the annual yield will be 3,338 green tonnes/year. During the next 30 years stands becoming overmature in 10 year periods could be removed. Annual volume estimates for each 10 year period could be 3,045, 2,255, 2,065 green tonnes/year respectively.

There are four regeneration options available depending on the size of opening created and soil drainage. These include:

(1) natural regeneration through coppicing and suchering;
(2) planting of hybrid Poplar for energy forest;
(3) planting of conifers;
(4) natural regeneration of other hardwoods (residuals).

POTENTIAL BIOMASS FROM OTHER HARDWOOD WORKING GROUPS IN THE SOUTH EAST AREA

There are 28 ha. of other hardwoods in the area. Of this 4 ha. are managed as a sugar bush. The total volume on the other 24 ha. is 2,568 m^3. The minimum available biomass would be 26% of this total (ENFOR P. 152).

A high cull content could increase the available biomass to 75% resulting in a total biomass of between 668 m^3 and 2,003 m^3 (477 to 1,431 green tonnes).

This would be recovered over a 20 year period which would allow the residual hardwoods to serve as seed trees and permit the release of intermediate and suppressed trees on a gradual basis.

Over the 20 year period the available annual biomass volume would be between 24 and 71 green tonnes. When the branchwood biomass is added to this the gross biomass potential per year would be between 31 and 79 green tonnes.

POTENTIAL BIOMASS FROM CONIFER WORKING GROUPS IN THE SOUTH EAST AREA

Seventy-four percent of the conifer working groups are plantations. The remaining 26% include cedars and other scattered conifers. These stands are important in soil conservation and are not considered available for harvest.

The pine working groups are grown in plantations. The volume of conifers in Area 1, taken to a rotation age of 60 years, would be 32,699 m^3. Assuming very little cull in the plantation, the available biomass would be 19%* of the total volume. Over a 60 year period the available biomass would be 103 m^3/year or 59 green tonnes/year.

Regeneration of plantations will be artificial planting of nursery stock.

*Reference to ENFOR P.152.

BIOMASS POTENTIAL FROM BARREN AND SCATTERED AND UNCLASSIFIED LANDS IN SOUTH EAST AREA

There are 135 ha. of barren and scattered and 227 ha. of unclassified lands. These lands, if planted with Poplar and/or conifers, could provide about 647 tonnes of biomass per year in periods 3 and 4.

SUMMARY OF POTENTIAL BIOMASS FROM SOUTH EAST AREA IN GREEN TONNES PER YEAR 10 YEAR PERIODS

Working Group	Period 1	Period 2	Period 3	Period 4
Poplar	3,338	3,045	2,456	2,065
Conifer	59	59	59	59
Hardwood				
% C.A.I.	7	7	4	4
% Harvest	24-71	24-71	13-18	13-18
B & S, U.C.L.				
Poplar/Conifer	-	-	647	647
Totals	3,428-3,475	3,135-3,182	3,179-3,184	2,788-2,793

POTENTIAL BIOMASS FROM AREAS WITH MILITARY ACTIVITY

Forest management should be undertaken on these lands if only to maintain a healthy forest for military activities. The following chart shows the potential biomass recoverable from these lands based on data relative to the non-military areas.

ANNUAL YIELD IN GREEN TONNES PER 10 YEAR PERIOD
AREAS OF MILITARY ACTIVITIES

	Period 1	Period 2	Period 3	Period 4
Poplar	2,843	2,693	2,091	1,831
Conifer	564	564	564	564
Other Hardwoods	196-587	196-587	97	97
Barren & Scattered		Military Activity Only		
Totals	3,603-3,994	3,453-3,844	2,752	2,492

ANNUAL YIELD IN GREEN TONNES PER 10 YEAR PERIOD
ALL AREAS

	Period 1	Period 2	Period 3	Period 4
Poplar	6,181	5,738	4,547	3,896
Conifer	623	623	623	623
Other Hardwoods	227-665	227-665	110-115	110-115
Barren & Scattered	-	-	647	647
Totals	7,031-7,469	6,588-7,026	5,927-5,932	5,276-5,281

HARVESTING COSTS PER GREEN TONNE OF BIOMASS

Working Group	Management Prescription	Costs per Green Tonne At Landing*	At Hogger**
Poplar	Small clear cut openings	$ 6.20	$ 7.42
Other Hardwoods	Salvage cuts for cull plus hardwood residues	7.58-14.47	7.69-15.68
Conifers	Logging residue retrieval	7.58-14.47	7.69-15.68

* Computed from ENFOR P.19

** Computed from ENFOR P.19 - Chip Transport Cost Equation.

ASSESSMENT OF BIOMASS FROM ENERGY PLANTATIONS

The establishment of biomass energy plantations are very much in the experimental and conceptual stage. While considerable work has been done in the breeding, selection and evaluation of clones, no extensive blocks are being grown specifically to supply wood biomass to an energy system. The terms of reference have called for a review of the energy plantation potential and a discussion as to its role in the conversion system.

It would appear that, from the investigations being done into mill wastes, logging wastes and wastes derived from stand improvement and silvicultural practices, there are more than adequate wastes to meet the demands of the pilot conversion. However, with the interest generated in biomass utilization and an increased demand for wood, the planting of energy forests could well become a necessity in order to ensure a biomass reserve and a more constant and quality controlled supply.

This review looks into the energy plantation issue, identifying some of the constraints, and looks at the economics of growing biomass. The present thinking on energy plantations centres on the utilization of fast growing hybrid poplar species under mini or short rotation systems and under a mechanized and highly managed practice. In general, the "mini" rotations constitute a harvesting rotation of two to three years. This involves the harvesting of a large number of smaller stems on a two to three year cycle for about ten to twelve years before the root stock must be replaced. The short rotation involves a harvesting cycle of five to seven years extending over a fifteen to twenty year period.

While the technology to produce energy forests exists, there are several constraints in terms of lands suitable for energy plantation forests, the management and harvesting of poplar forests, the storage of biomass materials , and the economics of providing a sustainable supply.

THE LAND RESOURCES CONSTRAINTS

The site requirements for optimal growing of hybrid poplar are soils with textural ranges heavier than sandy loam with moist site conditions; some wetter sites can be used if ground water conditions are well below the surface. Further, if the mechanization of the energy plantation is to be achieved, steeply and strongly sloping lands cannot be utilized.

A review of the soils and topographic maps of the study area indicate that land resources which are not currently being utilized and which may be used for the growing of hybrid poplar are rather limited unless some agricultural lands are to be used. Much of the abandoned or vacant land is associated with either or both very steeply sloping lands or very sandy lands which are not suitable to the mechanization or the growing of hybrid poplar. While some parts of the vacant land may be able to grow hybrids, these constitute very small tracts.

It is estimated that there are about 60,700 ha. within a 40 km. radius of Base Borden which have soil and terrain conditions which would be well suited to growing poplars. However, much of these lands are being utilized for agriculture. Utilizing those lands which are poorly drained and not as well suited to agriculture, it is estimated that there are about 18,200 ha. that could be used in the growing of poplar. About 75% of these lands are under natural forests and would require clearing in order to be incorporated into an energy plantation program. Areas of these lands which could constitute a sizeable operational energy plantation have been identified in Medonte, Flos, Essa, Mara, Tay and Tecumseth Townships. A major block is identified on the southeast corner of the Base and extends into the Base itself. It is estimated there are about 800 ha. including lands within the Base. The lands outside the Base appear to be under private holdings.

OPERATIONAL CONSTRAINTS

While the operational framework and the decisions with respect to mini and short rotations are important, perhaps more critical to

the continuous supply of biomass are some key technical and biological constraints which control the harvest and the regeneration of the coppice growth.

It is important to the successful and healthy regeneration of the coppice growth that in harvesting, the stems are cut close to the ground. Further, it is important that this be done only in the fall and winter periods after the leaves have fallen and the plant is in a dormant state. These biological constraints seriously limit the harvest to the relatively short period of October and November when the plant is dormant and there is little or no snow on the ground. This also dictates the need and requirement for drying and long term storage facilities which must be considered, particularly if the total biomass requirement is to come from energy plantations.

COST OF PRODUCTION

Data on real costs of production under different systems are still rather limited, although several budgets have been developed which include site preparation and planting costs, material costs, annual management costs, harvesting and other costs in order to arrive at cost per ton of biomass.

In order to arrive at production costs, two systems are presented. This basic framework and some of the inputs are derived from existing economic analysis. Table 9 presents a budget estimate for a mini rotation hybrid poplar. Table 10 presents a budget for short rotation hybrid poplar.

The budget established for the mini and short rotation systems have been taken from earlier budgets and adjusted to current pricing. Materials were increased by 25%, whereas site preparation and harvesting were increased by 35% because of recent escalation in energy costs. Interest in operating capital was increased by 75%.

TABLE 11

BUDGET ESTIMATE FOR SHORT ROTATION HYBRID POPLAR

Cost Category	Estimate Average Cost/Year
1. Materials	
Cutting, clearing, herbicides, pesticides, fertilizer	$ 39.59
2. Site Preparation and Planting*	
Clearing, ploughing, discing, herbicides, planting	7.73
3. Annual Management**	
Fertilizer and pesticide applications	14.13
4. Harvesting	
Felling, bunching, hauling to chipper, chipping, loading	29.54
5. Other Costs***	
Land (rental or lease) interest on operating capital, miscellaneous (taxes, phone, automobile, etc.)	242.06
Total Costs	$333.05
Average cost/tonne @ 17.64 green tonnes/ hectare yield is	$ 18.88

* Because the time interval assumed between re-establishment is 42 years, the annual figures are 1/42 actual estimated costs per hectare.

** Fertilization in this system is assumed to take place after each harvest (7 years) thus annual figures are 1/7 actual estimated costs per hectare.

*** This system assumes to require bank loan financing at 12% interest for long term credit and 14% for short term credit.

TABLE 10

BUDGET ESTIMATE FOR MINI ROTATION HYBRID POPLAR

Cost Category	Estimate Average Cost $/Ha/Year
1. Materials*	
Cuttings, clearing, herbicide pesticide, fertilizer	$281.08
2. Site Preparation	
Clearing, ploughing, discing, herbicide, planting	142.77
3. Annual Management	
Fertilizer and pesticide applications	98.84
4. Harvesting	
Chipping, hauling, transfer	146.78
5. Other Costs**	
Land (rental or lease) interest on operating capital, miscellaneous (taxes, phone, automobile, etc.)	345.94
Total Costs	$1,015.41
Average cost/tonne @ 26.47 green tonnes/ ha. yield	$ 38.34

* Because the time interval assumed between re-establishment is 10 years, these annual figures are 1/10 of actual estimated cost/ha.

** This system was assumed to require bank loan financing at 10% interest for medium term credit and 12% for annual operating credit. Pay back of medium term principal forced into system to minimize interest charges.

Under the mini rotation system, biomass could be supplied at a cost of $38.34 per tonne. This is a break even price and does not include anything for risk, delivery and drying costs. Under the short term rotation, the estimated costs per tonne are considerably less, however, the yield over the long term is lower and hence the return is much less.

It would appear that in terms of a selling price, in order to compare the opportunity cost with, say pulp wood chips, the price for the wood biomass would have to be $84.00 per tonne. This price is comparable to pulp wood chip costs being received.

TABLE 11

SUMMARY OF VOLUMES OF POTENTIAL BIOMASS AVAILABLE BY SOURCE AND CURRENT DELIVERED COST PER TONNE AT BASE BORDEN PLANT

Huronia District		
Private Sector	3,045 m^3	$6.98-$14.23* per green tonne delivered at hogger
Agreement Forest	2,168 m^3	
Base Borden		
South East Area	3,428-3,475 green tonnes	$6.98-$14.23*per green tonne delivered at hogger
Military Area	3,603-3,994 green tonnes	
Poplar Plantation (i.e. 800 ha. block)		
Mini rotation @ 26.47 green tonnes per ha.	21,428 green tonnes/year	$38.34 per green tonne
Short rotation @ 17.64 green tonnes per ha.	14,285 green tonnes/year	$18.88 per green tonne
Mill Waste		
Sawdust	25,175 green tonnes	@ average price of $15.55 per green tonne delivered
Slabwood	13,050 green tonnes	@ average price of $30.86 per green tonne delivered

* ENFOR P.19

ENERGY PLANT

WOOD AS A FUEL

DESCRIPTION OF EXISTING BOILERS IN BUILDING No. 098

PROPOSED PLANT

ENERGY PLANT

WOOD AS A FUEL

Refuse wood is burned successfully in many type of boilers at wood mills, saw mills and in the pulp and paper industry.

The types and classes of refuse wood vary enormously. Two characteristics of wood which have a substantial effect on burning are moisture and size.

The moisture content can vary substantially and has a greater effect upon the problem of burning than all others. Kiln dried lumber may be 5%, cured lumber 1% to 15%, lumber mill waste 45% to 65% depending upon the operation. Refuse which has a moisture content greater than 55% requires hot combustion air (260°C to 288°C) to burn successfully. Wood with a moisture content of 65% will not burn properly in a boiler.(Reference "Wood as a Fuel - A.D. Smith, P. Eng. Canadian Boiler Society Publication-January, 1965.)

The heating values of wood also vary from as much as 4068 kJ to 4307 kJ per kg. of dry substance. At 50% moisture, a kg of wet fuel contains 0.27 kg of dry material which at 4068 kJ per kg dry basis would therefore only contain 2034 kJ per kg.(Reference- "Wood as a Fuel" - A.D. Smith, P. Eng. Canadian Boiler Society Pulbication-January, 1965.)

Wood size also varies from logs to fines, therefore the speed of burning varies greatly. The greater the uniformity of sizing, the better the control of combustion. For this reason, wood is usually hogged to a greater degree of uniformity. Bark from woods such as birch and cedar tend to be long and stringy. Other barks are chunky when taken off logs. Fines, such as sander dust and shavings must be properly mixed with other wood to ensure that there are no slugs of explosive mixtures.

WOOD AS A FUEL (Continued)

Sizing of the fuel as delivered to the furnace has a great effect upon the equipment to be chosen and the success of the operation.

The ash content of wood is very small and usually runs 1.5% to 2%. Bark often has clay mixed in with it due to dragging the logs through the forests. The clays form a hard ash clinker which is often difficult to remove from the furnace.

Wood Fired Boilers

Wood can be fired in a boiler by using a Dutch Oven attached to the boiler, pile burning in the furnace on a grate or combination suspension burning/pile burning.

A Dutch Oven is a rectangular firebrick lined box with a hearth which is usually an extension to a water cooled furnace. The refractory radiates heat back into the wet wood and the drying and combustion takes place within the oven. A water cooled furnace absorbs heat and does not radiate heat back into wet wood. Wet wood is difficult to burn in a completely water cooled furnace and some refractory must be installed to re-radiate heat back into the wood refuse.

Fuel enters the Dutch Oven through a hole in the furnace roof. The products of combustion exit through a port at the rear of the oven and enter the boiler furnace. The fuel piles up on the oven floor. Combustion air enters the oven through holes in the floor grate and air ports along the side and rear of the oven. The air is usually difficult to control and large quantities of excess air enter into the oven. Excess air values generally run around 100 - 150% so that a great deal of particulate is carried off and emitted.

WOOD AS A FUEL (Continued)

Wood Fired Boilers (Cont'd)

As with all pile burning in a furnace, there is no direct relationship between fuel flow and rate of steam output. Such control as is required is obtained from varying the air flow, resulting in smoke and varying steam pressure.

In order to remove ashes, the oven must be allowed to burn down.

Wood refuse can be burned on a grate within the boiler furnace. The wood can be fed onto the grate by means of a screw conveyor beneath the grate. The wood pile is fed from the bottom. Underfire combustion air is admitted under the grate and overfire air is admitted above the pile around the periphery of the furnace. The advantages claimed are lower particulate emmission and carryover because the fuel bed is relatively undistrubed. Excess air is also lower than that of the Dutch Oven. The excess air level is usually around 50 to 70%.

Wood is often burned in suspension and pile burning on a grate. The wood is admitted to the furnace either on a spreader stoker or air assisted ports. The fuel is thrown into the furnace. The lighter particles burn in suspension and the heavier particles fall on the grate and burn out. If the fuel moisture and consistency vary, it is difficult to get a uniform bed distributed across the furnace. The excess air level is usually around 50%-70%. The emission levels of this furnace are usually higher than that of a wood pile furnace. In this type of combustion, the rate of fuel firing is much more closely controlled to steam production requirements since there is little storage within the furnace.

The grate should be covered with ash at all times to prevent overheating, particularly where auxiliary oil and gas burners are used when there is no wood firing.

ENERGY PLANT

DESCRIPTION OF EXISTING BOILERS IN BUILDING No. 098

The boilers in building No. 098 are two John Inglis type VL water tubed boilers, designed and built in 1945 for coal firing. The operating pressure of the boiler is 620 - 689 kPa, boiler design is 1034 kPa and each rated at 5443 Kg/hr evaporation.

The boilers were equipped with an underfeed stoker, dump grates and ash pits. Approximately 8 - 10 years ago, the boilers were converted to natural gas firing and the coal firing equipment removed.

The grates were removed and the ash pits below the grate filled in with concrete. The furnace floor is completely lined with refractory to give a flat floor.

No other modifications were made to the pressure parts. The front wall plate was replaced and all doors into the furnace removed with the exception of one on the furnace side to allow entrance to the furnace for inspection.

No drawing of the boiler is available but based on some of our old records, we estimate the volume of the furnace at 9.2 m^3, heating surface 34.4 m^2 and the grate area as 3 m^2.

The burning rate for wood on pin hole grates on modern boilers is 83,313 kJ/m^2 to 98,015 kJ/m^2. These are very high rates leading to considerable particulate carryover.

DESCRIPTION OF EXISTING BOILERS IN BUILDING No. 098 (Continued)

At a peak steam load of 5,443 kg/hr on one boiler, the grate heat release rate is 628,813 kJ/hr. We would prefer to keep the grate heat release rate at an average of 316,517 kJ/hr which corresponds to a steam rate of 3,629 kg/hr. The heat release per m^3 of furnace volume at this load is approximately 1,195 kJ/m^3. The boiler could make 5,443 kg/hr on wood provided the wood is dry(which is unlikely). However, at this steam load, a great deal of particulate carryover would be experienced, resulting in the boiler plugging with ash and char.

Normally, boilers of this vintage were rated at 1.26 $kg/hr/m^2$ of grate surface with a good free burning coal at 6,460 kJ/kg calorific value. This would result in a boiler capacity of approximately 5,443 kg/hr.

In order to meet the peak loads during the heavy heating period, both boilers would have to be operating.

The boiler was originally designed as a balanced draft boiler. This feature has been maintained. The furnace draft is held slightly below atmospheric pressure by means of an outlet damper and an induced draft fan on the boiler outlet. The induced draft fans for each boiler exhaust into individual stacks.

Examination of the boilers, induced draft fans and breeching indicated that the equipment was in good condition. There were only two hot spots observed on the boiler casing at the front wall which can be easily repaired. There have been no reports of tube damage due to water treatment problems.

DESCRIPTION OF EXISTING BOILERS IN BUILDING No. 098 (Continued)

Normally, only one boiler is fired at a time except in periods of extremely cold weather when the second boiler is fired to reduce the peak duty on the boilers.

Figures for annual fuel consumption and steam production for these boilers are as follows:

Annual Gas Consumption	- 897,331 m^3
Annual Steam Production	- 10,875,331 kg
Annual Fuel Bill	- $108,693.00
Estimated Average Boiler Efficiency	= 75%
Estimated Cost of Fuel per MCM	= $121.00

(MCM= 1000 cubic meters)

ENERGY PLANT

PROPOSED PLANT

In order to burn wood refuse in the existing boilers, the following changes would have to be made:

1) Furnace alterations to suit lower heat value of wood versus gas/oil.
2) The induced draft fans changed to suit increased excess air requirements.
3) Dust collectors installed to meet air pollution requirements.
4) Stack height changed to meet air pollution requirements.
5) Wood handling facilities required.

These items result in a capital outlay of $1,862,000.00.

To maintain a continuous supply of wood refuse to the boilers requires additional manpower. This manpower is estimated to cost $113,750.00 annually.

Wood refuse is available at the following prices delivered to the site:

Sawdust - $16.53 per metric ton (1000 kg)

The difference in fuel cost is estimated as follows:

Gas Cost	- $108,693.00
Wood Cost	- 58,540.00
Difference	$ 50,153.00

PROPOSED PLANT (Continued)

The difference in fuel cost in favour of the wood firing disappears when the cost of labour is taken into consideration. Gas costs will escalate but so will the cost of wood refuse. Labour costs will undoubtedly escalate.

Even if there were no capital outlays, the extra labour costs cannot be offset by the difference in fuel costs.

Dust Collector

The particulate carryover from the boilers will increase due to wood firing. Dust collectors will have to be installed on the boiler outlets to reduce the amount of particulate carryover to meet the Air Management Regulations. The quantity of particulate must not exceed 100 micrograms per cubic meter at point of impingement for boiler exhaust.

Fires in dust collectors must be avoided. They are caused when hot char in the dust collector is agitated by fresh air. During unloading, if fresh air is allowed to enter the dust collector, fires ensue. To prevent this, either double air locks or rotary valves are used on the dust collector outlets.

Induced Draft Fans

The present induced draft fans do not possess sufficient draft for wood burning. The draft losses will increase due to the dust collectors and breeching.

The present induced draft fans are rated at 297 cu. meters per min. at 19 kg/m^2 S.P. - 316^{o}C -1150 RPM.

Two new induced draft fans would be installed, each rated at 283 cu. meters per min. at 152 kg/m^2 S.P.

PROPOSED PLANT (Continued)

Stack

The existing chimney stacks will not meet the Air Management Requirements for atmospheric pollution. Until an application is submitted to the Ministry, an approval cannot be obtained. However, for the purposes of the study two stacks, 7.62 meters tall have been selected which will carry the products of combustion clear of the building envelope. Since there is no sulphur dioxide in the products of combustion, the criteria which apply are: dust loading, smoke and nitrous oxides.

The stacks would be steel insulated stacks, supported on the roof.

Furnace Changes

It is proposed that the existing gas burning facility be maintained in the furnace front wall. Wood fuel would be fed into the furnace via a screw feeder below the refractory grate. The fuel would be burned in a pile within the furnace.
Underfire combustion air would be admitted below the refractory floor which would be constructed from a poured floor with numerous 2.54 cm diameter holes cast vertically through it.

Ash pit doors would be constructed on the side of the furnace below the side wall headers and on the front wall. Overfire air would be introduced along the side walls of the furnace above the main water wall headers.

The screw feeder would be variable pitch type to reduce the incidence of plugging.

PROPOSED PLANT (Continued)

Furnace Changes (Continued)

The wood fuel would be fed into a hopper in front of the boiler enabling the operator to observe the fuel flow.

The screw feeder drive would be controlled in relationship to the steam demand.

There is at present a tangential spin furnace which has been developed and claims to be capable of burning wood chips. If it is successful, it would also be considered for firing these boilers.

Wood Handling System

Wood refuse would be delivered to the site, most likely sawdust and bark. However, in order to allow D. N. D. to purchase wood refuse from any supplier, the wood handling system would be designed to accommodate large pieces of wood refuse.

Wood would be delivered to C. F. B. Borden by trucks and dumped into a receiving bin on the south side of Building No. 098. Approximately 2 (two) days storage (87 metric tons) would also be kept in a receiving area on the south side of building No. 098. Approximately one month's storage (1306 metric tons) would be kept at other storage areas around the base camp. This would allow for interruption from the wood suppliers due to snow storms and road restrictions in the fall and spring.

PROPOSED PLANT (Continued)

Wood Handling System (Continued)

The wood in the receiving area would be picked up by a front end loader and dumped into a receiving bin which has a live bottom rated at 181 metric tons per hour. The wood is then dumped onto a conveyor and conveyed to a disc screen. The disc screen would have openings of approximately 2.54 cm between discs through which the smaller pieces fall through. The larger pieces are discharged onto a chute which leads to a hogger where they are chipped to size. A magnet at the head of the conveyor removes all tramp iron.

After hogging, the wood is discharged to a stock pile which is enclosed in a building. The stock pile should have a minimum of four (4) days storage. Sawdust would be delivered directly to the storage building.

The hogged fuel is protected from the weather by the building. The fuel is reclaimed to the conveying system by means of a front end loader. The front end loader will be in use on a 24 hour basis seven days per week throughout the winter. Automatic reclaiming for such a small operation is expensive. Automatic reclaim can be successfully used where large quantities of fuel are involved. A hydraulic ram, screw feeders or chain feeders placed under the fuel are used. In general, reclaimed fuel does have problems with continuous feed and some manual supervision is required.

The reclaimed fuel is fed to the boiler storage bin through a dryer. There are numerous installations which do not use dryers. The wood is dried in the boiler furnace. However, the boiler efficiency is reduced, the wood is difficult to burn, it tends to smoke, particulate carryover is increased as the hot char takes longer to burn and the amount of excess air has to be increased in the furnace.

PROPOSED PLANT (Continued)

Wood Handling System (Continued)

The hot gases leaving the furnace at 232°C are directed through the dryer where they meet the fresh fuel. The wood is dried from 55% moisture to approximately 43%. From the dryer, the wood is discharged to the boiler storage bins.

The possibility of fire within a direct contact dryer exists. Hot char will exit from the boiler and although dust collecors should be installed on the boiler outlets, hot char will pass through the dust collector and into the dryer. Usually, the quantity of inert gases within the dryer prevent combustion taking place, however, if fresh air is admitted, a fire can happen.

The boiler storage bins are designed to hold 1.36 metric tons which represents three-quarter hour storage at maximum load. Feeders within the bin, discharge fuel to the boiler feed, which is an undergrate feed system.

Ash Removal

The quantity of ash produced by wood firing is approximately 680 kgs per day, of which approximately half will be on the grate and the remainder in the dust collectors. The ash on the grates may tend to clinker depending upon the amount of clay picked up by the wood.

To remove ash, one boiler would be allowed to have the wood pile burn down while the other is in operation. The ash would be removed from the grate by raking the ash into a wheel barrow and dumped outside where it would be removed by the front end loader.

PROPOSED PLANT (continued)

Ash Removal (continued)

Fly ash would be removed from the dust collectors through an air lock dumped by gravity outside.

The fly ash from wood firing is abrasive. Pneumatic handling systems for ash removal are installed on large boilers but for boilers of this size, wheel barrows are in common usage.

Labour Costs

The wood handling would require an increase in labour force of five (5) men. On the basis of an eight hour shift for seven days a week, four men are required for a five day week plus sickness time and vacations. One man will be required for maintenance on day time shift. He would also be used for operations during vacations and sickness.

Current Labour rates are as follows:

4th Class Stationary Engineer	- $ 8.75/hr
3rd Class Stationary Engineer	$ 9.85/hr
2nd Class Stationary Engineer	$11.21/hr

Only 4th class stationary engineers would be required for this work or alternatively, tractor operator. Overhead is estimated on the basis of three weeks sick leave, three weeks vacation and eleven statutory holidays plus pension plans, etc. as 25%.

Annual Labour Costs

No. of Men	= 5
Hourly rate ($8.75 + 25%)	= $10.93
Annual Hours	= 2080
Annual Labour Costs	= 5 x $10.93 x 2080
	= $113,750.00

PROPOSED PLANT (Continued)

Fuel Costs

Currently, natural gas is purchased for $121.00 per MCM and oil for $0.26 per litre. Thus on a kJoules basis, the costs are as follows:

Natural Gas per 1,000,000 kJoules	- $3.62
No. 2 Oil per 1,000,000 kJoules(48,780/litre)	$6.02
Wood 43% moisture per 1,000,000 kJoules	$1.62

Annual fuel bill based on 10,875,331 kgs Steam =

Wood - Cost of 3541.6 tons at $16.53/ton	= $ 58,540.00
Labour Cost	113.750.00
	$172,290.00
Gas Cost	$108,693.00
Net Difference in favour of Gas	$ 63,597.00

PROPOSED PLANT (Continued)

Capital Costs

Capital cost of the installation is estimated as follows:

a) ITEM	MATERIAL	LABOUR
Receiving Bin	$ 80,000.00	
Chain Conveyor & Magnet	25,000.00	
Disc Screen	20,000.00	
Hogger	45,000.00	
Civil & Structural Work	75,000.00	
Equipment Rentals	25,000.00	
		$75,000.00
Sub totals	$270,000.00	$75,000.00
Provincial Sales Tax	20,000.00	
	$290,000.00	$75,000.00

Total Material + Labour	= $365,000.00
20% Contingency	72,000.00
TOTAL	= $437,000.00

This portion of the installation would be required if wood refuse other than sawdust were purchased. If only sawdust was purchased then this equipment would not be required.

PROPOSED PLANT (Continued)

Capital costs (Continued)

b) ITEM	MATERIAL	LABOUR
Civil and Structural	$250,000.00	$
Storage House	75,000.00	
Conveyors & Dryer	150,000.00	
Feeders	35,000.00	
Boiler Storage Bin	40,000.00	
Furnace Changes	50,000.00	
Dust Collectors	50,000.00	
I. D. Fans	25,000.00	
Stacks	12,000.00	
Breeching	40,000.00	
Insulation	10,000.00	
Electrical Service	45,000.00	
Control System	30,000.00	
Front End Loader	40,000.00	
Equipment Rentals	25,000.00	
		$250,000.00
Sub Totals	$877,000.00	$250,000.00
Provincial Sales Tax	61,000.00	
	$938,000.00	$250,000.00

Total Material + Labour = $1,188,000.00
20% Contingency 237,000.00
TOTAL $1,425,000.00

TOTAL of (a) and (b) = $1,862,000.00

Interest Charges on the Capital at 10% per annum = $186,200.00

PROPOSED PLANT (Continued)

Electrical Power Requirements

The new wood handling facility would require a larger electrical service in Building No. 098. The increase in power is estimated as follows:

		Connected	Operating
Lighting		5.0 KW	3.0 KW
I. D. Fans	10 HP	7.5 KW	5.0 KW
Hogger	150 HP	112.0 KW	33.0 KW
Disc Screen	10 HP	7.5 KW	5.0 KW
Conveyors	20 HP	15.0 KW	7.0 KW
Intake Hopper	20 HP	15.0 KW	7.0 KW
Total	210 HP	162.0 KW	60.0 KW

Connected Load = 162.0 KW

Estimated Electrical Operating Load = 60.0 KW

Annual Consumption based on 3000 hrs operation = 3000 x 60

= 180,000 KW. HR.

Annual Cost based on an average figure of $.03/KW.HR. = 3000 x 60 x $.03

= $5,400.00

Annual Electrical Increase in Cost for Wood Handling Facility = $5,400.00

CONCLUSIONS

An objective of this study was to determine the feasibility of supplying wood fuel to a wood-fired boiler at Base Borden. A number of sources were investigated including logging and milling residues, the harvesting of natural forest materials and biomass production from future hybrid poplar plantations. While each source would have the capacity to supply sufficient biomass and would be technically possible, the economics at this time indicate that only the mill waste is a viable and reliable source of supply.

The economics of burning wood waste are not favourable in comparison to gas firing. The increased capital cost and labour costs are not offset by the lower fuel cost. If the plant had the original coal handling facilities in existence, then the wood firing could be an attractive proposition at some other installation where there would be no increase in labour.

REFERENCES

1. Growth & Utilization of Poplars in Canada
Department Publication No. 1205
Forestry Branch, Department of Forestry and Rural Development.

2. Aspen, Symposium Proceeding. USDA Forest Service General Technical Report No. 1, 1972

3. Silvical Characteristics of Balsam Poplar
Lake States Forest Experiment Station
Forest Service, U.S. Department of Agriculture
Station Paper No. 65, June 1958.

4. Evaluating the Growth Potential of Aspen Land in Northern Minnesota
Lake State Forest Experiment Station
Forest Service, U.S. Department of Agriculture
Station Paper No. 86, December 1960

5. Summary of Green Weights and Volumes for Five Tree Species in Michigan
USDA Forest Service Research Paper No. 191

6. Biomass Production from the Harvesting of a Tolerant Hardwood Stand in Algoma, Ontario
D. A. Cameron, Metcam Forestry Consultants Inc.
ENFOR Project P-152.

7. Cost Estimates of Forest Biomass Delivered at the Energy Conversion Plant - N. A. Wiksten and P. G. Prins
ENFOR Project P-19.

8. Economic Potential of Hybrid Poplar-Based Fibre Production as an Agricultural Enterprise in Eastern Ontario
Wayne C. Pfeiffer, School of Agricultural Economics and Extension Education, University of Guelph, and Timber Sales Branch Forest Resources, Ontario Ministry of Natural Resources.

9. Biomass Inventory of Tolerant Hardwoods in Algoma, Ontario.
J. B. Thomas - ENFOR Project P-21

10. Effects of Spacing and NK Fertilizers on Dry Matter Accumulation and Nutrient Content of Two Year Old Popolus x Euramericana CV 1-45/51 and CV Robosta DN 17
George E. Ogar, ENFOR Project P-121

11. Forest Resources Inventory 1957 Report No. 20 of the Lake Simcoe District - Divison of Timber Management Ontario Department of Lands and Forests.

12. Burlington, Vermont Refuse Wood Power Plant, Aquaculture Greenhouse - A conceptual study Henningson, Durham and Richardson Inc. December 1977.

13. Energy in the Forest Industries
Ian E. Efford and S. M. Pneumaticos
Conservation and Renewable Energy Resources
Department of Energy, Mines and Resources, Ottawa

14. Soil Survey of Simcoe County, Report No. 29 of the Ontario Soil Survey, Canada Department of Agriculture, Ottawa, Ontario Department of Agriculture, Toronto 1962.

15. A survey of Custom Farmwork Rates Charged in Ontario, 1981
Economics Branch, Ontario Ministry of Agriculture and Food, Toronto 1982.

16. Land Capability for Forestry
Canada Land Inventory
Department of the Environment, Lake Simcoe 31D.

17. Wood as a Fuel
Arthur D. Smith, P. Eng. Chief Engineer, Steam Division, Foster Wheeler Ltd.
Presented for Canadian Boiler Society, Toronto, January, 1965

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BULK STORAGE BUILDING

NEW LOADING RAMP

NEW RECEIVING BIN

NEW CONVEYOR

NEW CONVEYOR CAP 3T/HR

NEW BREECHING FROM NEW DRYER TO NEW STACKS

NEW BREECHING FROM EXIST BOILER TO NEW DRYER

NEW CONVEYOR CAP 20 T/HR (DRAG)

NEW DRYER BYPASS & DAMPER, TYP.

NEW PLATFORM & STAIRS

EXISTING BOILERS

EXISTING STORE ROOM

PUMP ROOM

ENGINEERS OFFICE

WASHROOM

NEW HOGGER

NEW DRYER

NEW SCREW CONVEYOR

NEW PLATFORM

NEW STORAGE BUNKER

SCALE 0 2000 4000 6000 8000 10,000 MM

EXISTING MEZZANINE ELEV 118'-0"

NEW I.D. FANS

EXISTING DEAERATOR

EXISTING RAISED PLATFORM

EXISTING BOILERS

I.D. FAN MEZZANINE

GENERAL ARRANGEMENT - PLAN

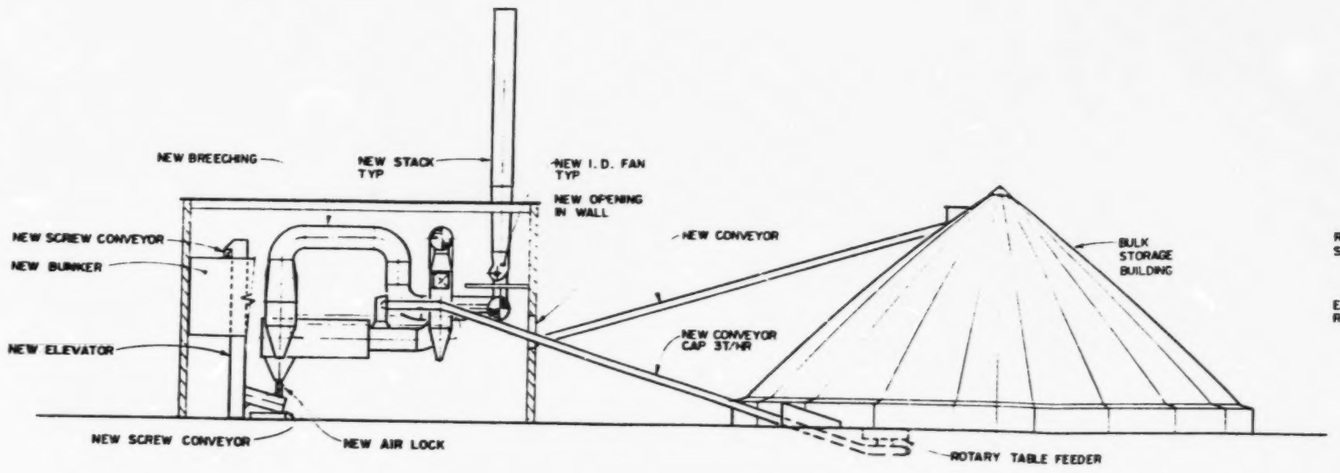
DATE	SYM	REVISION RECORD	BY	AUTH

CHARLES G TURNER & ASSOCIATES LTD

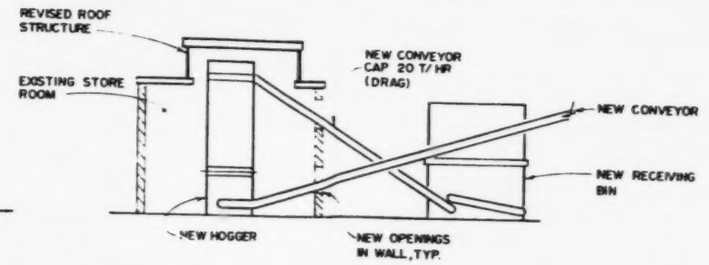
PROJECT
CFB BORDEN-FEASABILITY STUDY
CONVERSION OF OIL GAS HEATING
PLANT TO BIOMASS FUEL

P-3 MATERIAL HANDLING SYSTEM
P-2 GENERAL ARRANGEMENT - SECTIONS
REFERENCE DRAWINGS

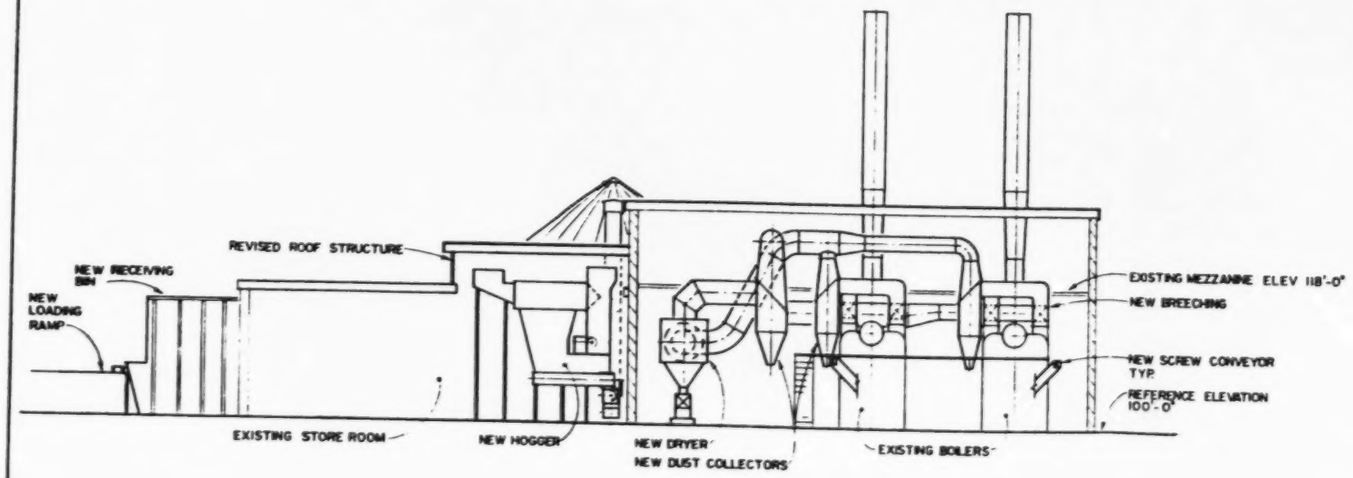
DATE	DWN BY	CHECKED	SCALE	DWG N°
APRIL 82	M.Tseko	P.K.	1:100	P-1



SECTION B B



SECTION C C



SECTION A A

SCALE 0 2000 4000 6000 8000 10,000 MM

GENERAL ARRANGEMENT - SECTIONS

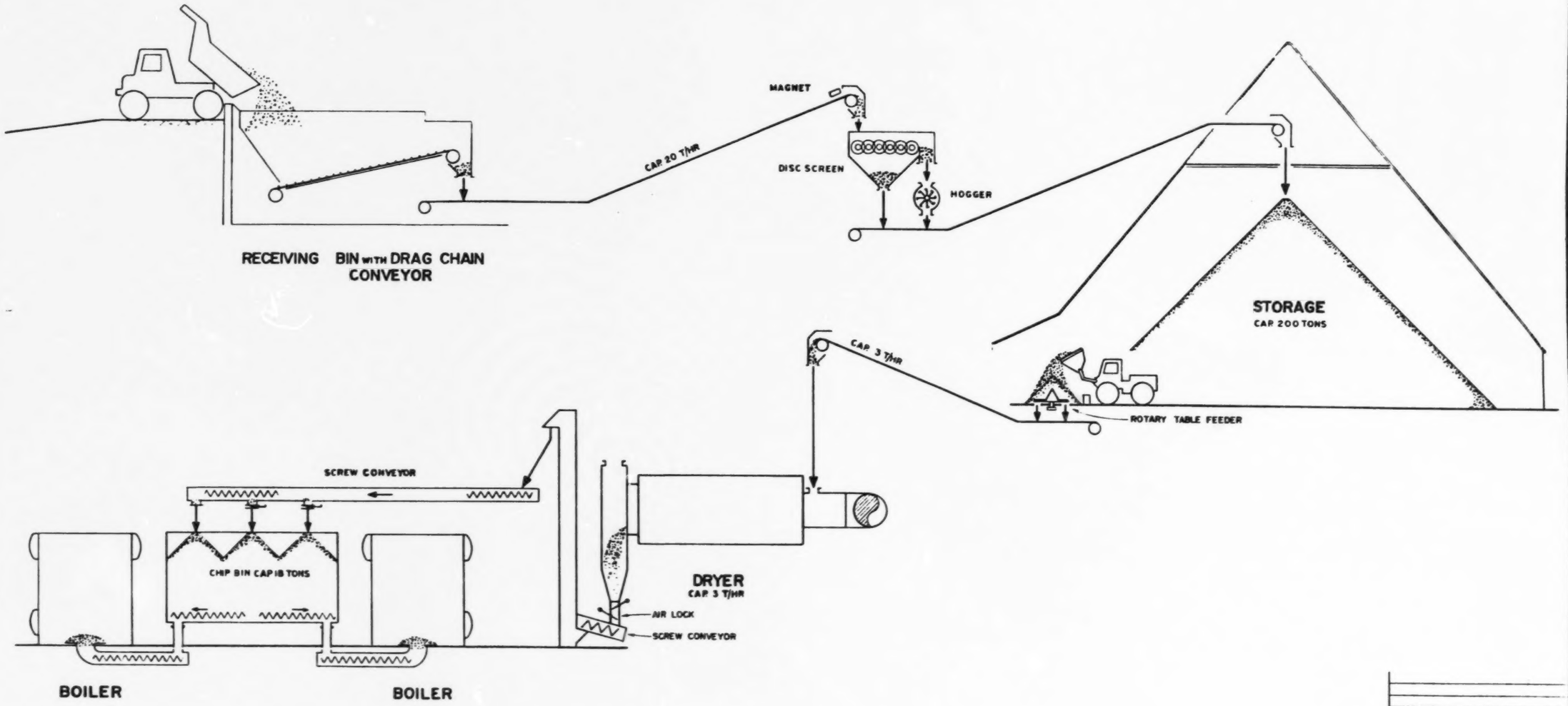
DATE	SYM	REVISION RECORD	BY	AUTH

CHARLES G TURNER & ASSOCIATES LTD

PROJECT
CFB BORDEN-FEASABILITY STUDY
CONVERSION OF OIL GAS HEATING PLANT TO BIOMASS FUEL

P-1 GENERAL ARRANGEMENT - PLAN
REFERENCE DRAWINGS

DATE	DWN BY	CHECKED	SCALE	DWG Nº
APRIL 82	MJ.eld	P.K.	1:100	P-2



MATERIAL HANDLING SYSTEM

DATE	SYM	REVISION RECORD	BY	AUTH

CHARLES G. TURNER & ASSOCIATES LTD.

PROJECT:
C.F.B. BORDEN-FEASABILITY STUDY
CONVERSION OF OIL/GAS HEATING PLANT TO BIOMASS FUEL

P-1 GENERAL ARRANGEMENT - PLAN
REFERENCE DRAWINGS

DATE:	DWN BY:	CHECKED	SCALE:	DWG Nº
APRIL 82	MJveRO	P.K.	NONE	P-3

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